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Traditionally science and technology have been fields in which almost no women were employed. In recent years increasing numbers of women have been attempting to enter these fields. Affirmative action, equal opportunity and similar legislation have been enacted in an attempt to facilitate the entry of women. One of the purposes of this paper is to report briefly on a study designed to evaluate the success of women pursuing scientific careers. Since the results of this study are not encouraging, we are led to question why. The answer is likely a combination of many factors. One argument, which is invoked in response to this question, is that which claims that innate differences, besides the obvious physical ones, exist between the sexes and account for women's apparent inability to progress in scientific careers on a basis equal to that of men. The major portion of this paper will be concerned with this controversial issue.

The National Science Foundation published in 1978 the results of a five year study concerning the success of women who have pursued scientific careers.[1] The report states that despite equal opportunity and affirmative action laws, the gap between women's and men's wages continues to widen. Women's salaries are less than those of men at every degree level, in every field, in every employment setting, at every age, and in every activity. Furthermore, the difference increases with age. The report says that the salary gap between men and women has actually widened over the five years of the study (1972-1977). The unemployment rates for women scientists continue to be two to five times higher than those of men. The study found that though women are almost 16% of all scientists and engineers employed at colleges and universities, they are more likely than men to be employed at junior faculty and nonfaculty research associates rather than as tenured faculty. They are also more likely to be employed in two-year and four-year colleges and less likely to be in universities than men. Even among women who have attained faculty status, progress up the academic ladder still lags behind that of men, including the more recent male Ph.D.'s. Reports continue to show that this trend of women making less progress in their scientific careers than men has not reversed itself.[2]

Upon what evidence do those who argue that these results are indicative of innate sex differences, besides the obvious ones, base their claim? The differentiation of an individual into a male or female appears to be both a physiological as well as a psychological process. Research into the relationship between the two is still at an early stage.

Physiologically the process of human sexual differentiation occurs as follows.[3] At conception the individual's sex is genetically determined. Sex hormones begin to be secreted as the embryo develops and the gonads make their appearance. These hormones are responsible for the sexual differentiation of other bodily organs, among these is the brain.[4] If androgen, a male hormone, is present, the brain differentiates as male; if absent, female. One result of this brain differentiation is that males exhibit a lack of cyclic hormone release found in females and known to be controlled by a particular portion of the brain.[5]

Studies with animals have shown that the action of the testosterone, a male hormone, on the developing brain during a critical period has been implicated in the sexal differentiation of behavior.[6] For example, if testosterone is injected into a newborn female rat, the normal sexual receptivity is permanently lost even when later large injections of female hormones are given. Researchers have also found individual variation in sexual characteristics of adult female mice which is traceable to differential exposure to testosterone during prenatal development because of intrauterine proximity to male fetuses.[7] From studies such as the above it appears that a clear relationship exists between brain differentiation and sexual behavior in these animals.

Is this brain differentiation documented by anatomical differences? Experimental evidence leaves little doubt that there are indeed structural differences between male and female brains. Studies with rodents have shown anatomical differences in the brain between the sexes.[8] Furthermore electrophysiological techniques have been used to demonstrate that certain neurons in male rats receive more synaptic connections from certain parts of the brain than similar ones in females.[9] At this time it is not known whether these anatomical differences in the brain and nervous system are related to sex differences in behavior and other functions. However, in the case of song birds, e.g. the zebra finch and the canary, rather large and pervasive anatomical sex differences in the brain appear to lie behind behavior differences of the sexes, other than those associated with mating and care of the young."[10]

In humans anatomical asymmetries are observed in the brain and there is evidence that there may be sex differences in the distribution and extent of these asymmetries.[11] Many of these human asymmetries are easily observed with the naked eye on post mortem specimens and others found in living human specimens by radiological methods. [12] These studies have shown that the asymmetries appear to be distributed along a continuum, i.e., the region which is larger on one side may vary from being only slightly larger to, at times, being many times larger. [13] Interestingly, the asymmetries seem to be inborn, because they are already present in the fetus, and to differ with the sex of the individual.[14]

Scientists also have evidence that certain cerebral functions are linked to one hemisphere of the brain or the other,[15] although not all the work in this area is reliable.[16] Language, handedness, musical talents, visuospatial abilities, attention, and emotion all appear to be activities in which hemispheric dominance effects are prominent.[17] Some research efforts have been directed to finding anatomical correlates of cerebral dominance. For example, the area (planum temporale) associated with linguistic abilities, traits which are linked to the left hemisphere of the brain, has been found to be generally larger on the left side of the brain than the same area on the right. It is not yet known whether an individual with superior linguistic abilities has a larger left planum temporale than the average individual.

Recently the term "dominance" has taken on an almost relative meaning when used in reference to the two hemispheres of the brain. Isak Prohovnik in a recent review article writes:

> . . .we generally assume a hemisphere to be dominant for a task if it performs it better or faster than the other hemisphere, if localized lesions in it impair performance more than lesions in the other hemisphere, or if we have other physiological evidence for greater involvement and importance of this hemisphere for this task than the other hemisphere.[18]

Experimentally the evidence for a lateralization of many cognitive functions in the brain comes from diverse sources. Among these sources are studies in patients with discrete hemispheric lesions caused by disease or injury;[19] studies in split-brain patients whose cerebral hemispheres have been surgically isolated by the severance of connections between the two as a relief of epilepsy;[20] studies of the patients' responses that follow electrical stimulation of various sites in the brain;[21] and studies involving the lateralized presentation of sensory information in normal subjects.[22]

Out of such studies it has become apparent that each hemisphere has its own specialized talents. In general, sequentially ordered stimuli, such as words, are best handled by the left hemisphere while the analysis of simultaneous spatial relations such as those present in complex patterns is best carried out by the right hemisphere.[23]

It is well known and documented that the human brain controls the cyclic and noncyclic release of hormones in females and males respectively. The differentiation of the brain for that end is not disputed. The extent and distribution of human brain asymmetries, as mentioned earlier, shows anatomical brain differences between the sexes. Recently some research effort has been directed to ascertaining whether or not the sexes show a difference in the performance of tasks linked to one cerebral hemisphere or the other. Numerous articles have appeared.[24] The reported results are mixed. However, it does appear that there are differences in cognitive abilities between the sexes which could be linked to anatomical and physiological differences in the brains of males and females.

Richard Restak summarizes the results of many studies showing behavioral differences between the sexes.[25] He attempts to link these behavioral differences between the sexes to differences in the brain or its functioning. For example, girls, in contrast to boys, show enhanced verbal abilities, a trait associated with the left hemisphere. Girls learn to speak at an earlier age, they possess larger vocabularies than boys, and they rarely demonstrate speech defects.[26] Stuttering, for instance, occurs almost exclusively among boys. Some researchers claim that the real divergence between the sexes in regard to verbal ability begins at about age eleven with female superiority increasing through high school and beyond.[27] Girls learn foreign languages easier and are more likely to enter occupations involving language mastering.[28]

The findings of sex differences in verbal abilities during development are reinforced by studies of brain damage.[29] Three times more men than women showed language disturbances when their left hemispheres were damaged. According to McGlone, the researcher involved in the study, these findings "support the view that women show a more heterogeneous pattern for speech representation within the brain than is found in men."

The attentional mechanisms differ between the sexes.[30] Generally, females are more attentive to social contexts: faces, speech patterns and tones of voice. By four months of age, a female infant can distinguish photographs of familiar people, a task rarely performed well by boys of the same age. at four months, the female infant will babble to her mother's face, seemingly recognizing her as a person. The attentional mechanisms of boys are different, with nonsocial stimuli competing equally with social stimuli in eliciting responses. A male baby will more often ignore the mother and babble to a toy or a blinking light, fixate on a geometric figure, and, at a later point, manipulate it and attempt to take it apart.

Boys tend to be more curious, especially in exploring their surroundings, and they are better at manipulating three-dimensional space.[31] When boys and girls are asked to mentally rotate or fold objects, the boys will overwhelmingly outperform girls. Boys will say that they folded them in their minds. Girls, when explaining how they perform the same task, are likely to produce elaborate verbal descriptions, which because these are less appropriate to the task, result in frequent errors. This phenomenon has been closely linked to the hemispheres of the brain. Ordinarily, when a person is not involved in a mental task, the brain hemispheres show a synchronous rhythm. When the person becomes engaged in a mental task, the activated hemisphere will show a change in its electrical background and become desynchronized. When boys are involved in spatial tasks, such as manipulating three-dimensional space, the right hemisphere is activated consistently. In contrast, the left hemisphere in girls is activated when they are performing tasks employing spatial concepts. The apparent use of the left hemisphere by girls for both verbal and spatial processes may produce an interference phenomenon in which the use of words to solve a spatial problem results in slowed or incorrect responses.

This male superiority on visual-spatial tasks is most noticeable in adolescence and adulthood.[32] Men are consistently found in those occupations requiring a higher degree of facility in spatial tasks, e.g. engineering, physics and architecture, while women are poorly represented. Restak suggests that this might be remedied by the introduction of teaching methods involving verbal and linguistic approaches to these fields for women.[33]

Females are more proficient at fine motor performance and can carry out rapid sequential movements quickly and more efficiently than boys.[34] Again the left hemisphere is linked with tasks involved in sequential analysis. On the other hand, boys are less proficient in performing fine motor performance but do better in gross total body movements, especially those requiring fast reaction times.[35]

While boys seem more curious and appear to have greater enjoyment in exploring their environment, girls tend to favor a "communicative mode" in gaining knowledge about the world.[36] They favor asking others, taking advantage of other people's experiences and sparing themselves the need to encounter personally all the objects in their environment. Interpersonal skills appear at an earlier age and form the basis for the "communicative mode" most women maintain throughout their lifetime.

Apparently sex differences are involved in the fact that 95% of hyperactive children, or "learning disabled" children, are males. Restak explains this in light of the sex differences in brain function as follows:

> The male brain learns by manipulating its environment, yet the typical student is forced to sit for long hours in the classroom. The male brain is primarily visual, while classroom instruction demands attentive listening. Boys are clumsy in fine hand coordination, yet forced at an early age to express themselves in writing. . .. In essence, the classrooms in most of our nation's primary grades are geared to skills that come naturally to girls but develop very slowly in boys. The results shouldn't be surprising: a learning disabled child who is also frequently "hyperactive".[37]

The psychological process of human differentiation into male or female is thought to depend greatly on learning, cognition and social conditions.[38] Because of these, physiological influences on human behavior are believed to be rather difficult to isolate and interpret. This certainly has been a disturbing question when attempting to evaluate sex differences. Recent research involving identical twins raised apart indicates that the effect of the environment on human behavior may not be as great as thought.[39] This unprecedented study involves a team of psychologists, psychiatrists, sociologists and physicians to probe and analyze every conceivable aspect of the twins' life histories, physiology, tastes, psychological inclinations, abilities and intelligences. Presently nine sets of identical twins raised apart have been studied but more pairs of twins will be researched in the future. The researchers were amazed at the astounding similarities between twins raised apart in very different environments. To cite an example of a pair of twins with dramatically different backgrounds: one was raised as a Catholic in Nazi Germany by his grandmother; the other was raised as a Jew in the Caribbean by his father and spent part of his youth on an Israeli kibbutz. Both show the same domineering and authoritarian personality. They share many idiosyncrasies, e.g. both like spicy foods and liquors, are absentminded, think it is funny to sneeze in a crowd of strangers and flush the toilet before using it. Even though each was raised in a different culture and spoke a different language, the examiners were struck by the similarities in their mannerisms, the questions that they asked and the way they did things. In another case, twins who had been brought up in different emotional environments - one was raised in a strict disciplinarian household and the other in a warm, tolerant, loving home - show very similar neurotic and hypochondriacal traits. Even though the findings are still considered tentative by the researchers, they feel it safe to hypothesize that native ability will express itself over a broad range of environments and that the environment has to be severly impoverished or greatly enriched to change significantly its expression.

Anthropologists generally believe that human thought processes are to a large extent culturally determined and often point out just how far removed the thinking of a particular culture is from our own ordinary modes of thought. At the same time they usually hold that the human brain functions the same re-

gardless of cultural differences. Several explanations regarding this paradox are cited by Paredes and Hepburn but none have proved to be altogether convincing.[40] Recent studies on cerebral lateralization among Native American Hopi and Navajo Indians may shed a new light on this subject.[41] This recent research indicates that lateralization for language in the Hopi and Navajo differs from that in Anglo subjects. Language processing seems to occur in the right cerebral hemisphere in these Indians while linked to the left hemisphere in Anglos. Research in this area is just beginning and is preliminary. In Anglos the area of linguistic abilities, the left temporale of the brain, is known to be larger than that of the right and appears to be inborn. So far no similar research on the anatomical features of the brains of Indians has been reported.

Margaret Mead was always intrigued by the question of sex differences and kept this question before her as she studied different cultures. She writes:

> In every known human society, the male's need for achievement can be recognized. Men may cook, or weave or dress dolls or hunt humming-birds, but if such activities are appropriate occupations, then the whole society, men and women alike, votes them as important. When the same occupations are peformed by women, they are regarded as less important. In a great number of human societies men's sureness of their sex role is tied up with their right or ability, to practice some activity that women are not allowed to practice. Their maleness in fact, has to be underwritten by preventing women from entering some field or performing some feat. Here may be found the relationship between maleness and pride; that is, a need for prestige that will outstrip the prestige which is accorded to any woman. There seems no evidence that it is necessary for men to surpass women in any specific way, but rather that men do need to find reassurance in achievement, and because of this connection, cultures frequently phrase achievement as something that women do not or cannot do, rather than directly as something men do well.[42]

This difference, the need of men for recognition, may be considered as one growing out of man's inability to give birth to a child, a concrete expression of creativity. Mead also found that whole societies had built their ceremonials upon an envy of women's role and a desire to imitate it.[43] It appears that this envy of the female has been immensely fostered by cultural arrangements.

By barring or discouraging women from certain professions, Mead claims, we as civilization become poorer.[44] Throughout history we have drawn on the gifts of women almost entirely in one way, i.e. in how they contribute to the continuance of the race. On the other hand men have been able to contribute not only to the continuance of the human race but also to civilization. Mead says of men:

> They have been asked to develop and elaborate, each in terms of his own ability, the structure within which the children are reared, to build higher towers, or wider roads, to dream new dreams and see new visions, to penetrate ever farther into the secrets of nature, to learn new ways of making life more human and more rewarding.

> And within the whole adventure there has been a silent subtle division of labour, which had its roots perhaps in a period of history when the creativeness of bearing children outweighed in splendour every act that man performed. . .In this division of labour, there was the assumption that bearing children is enough for the women, and in the rest of the task all the elaborations belong to men.[45]

Margaret Mead claims that every known society creates and maintains artificial occupational divisions and personality expectations for each sex that limit the humanity of the other sex.[46] She sees that characteristic after characteristic is artificially assigned as masculine or feminine even though the differences within the sex are so great that there is enormous overlapping. Mead writes:

> Throughout history, the more complex activities have been defined and re-defined, now as male, now as female, now as neither, sometimes as drawing differentially on both sexes. When an activity to which each could have contributed - and probably all complex activities belong in this class - is limited to one sex, a rich differentiated quality is lost from the activity itself. Once a complex activity is defined as belonging to one sex, the entrance of the other sex into it is made difficult and compromising.[47]

Mead notes that when an occupation, whether it be in the arts or the sciences, is restricted to one sex, a whole pattern of thought which is congenial to that sex and within which one must work is developed.[48] This pattern facilitates the performance of the expected sex while obstructing that of the unexpected sex. These patterns devised by one sex and congenial to that sex even restrict those of that particular sex after a time because they are not made new by the interwoven imaginations of both sexes. Mead writes:

> In all these complex achievements of civilization, those activities which are mankind's glory, and upon which depends our hope of survival in this world that we have built, there has been this tendency to make artificial distinctions that limit an activity to one sex, and by denying the actual potentialities of human beings limit not only both men and women, but also equally the development of the activity itself.[49]

Mead believes that once we accept the premise that we can build a better world by using the special gifts of each sex, we will then have two kinds of freedom, freedom to use untapped gifts of each sex and freedom to admit and cultivate in each sex their special superiorities.[50] She writes:

> We may well find that there are certain fields, such as the physical sciences, mathematics. . .in which men by virtue of their sex, as well as by the virtue of their qualities as specially gifted human beings, will always have that razor-edge of extra gift which makes all the difference. . .We may equally well find that women. . .have a special superiority in those human sciences which involve that type of understanding which until it is analyzed is called intuition. . .Once it is possible to say it is as important to take women's gifts and make

> them available to both men and women, in transmittable form, as it was to take men's gifts and make the civilization built upon them available to both men and women, we shall have enriched our society.[51]

Mead claims that the sciences are sadly lop-sided; they need to and are ready to synthesize both kinds of gifts, those of both sexes.[52] She believes that we can build a whole new society, one in which science continues to play an important role, if we use both those gifts special to each sex and those shared by both sexes, i.e. the gifts of the whole humanity.

This paper may not have answered the question of whether or not sex differences, besides the obvious physical ones, account for women's apparent inability to progress in scientific careers on a basis equal to that of men but perhaps it has opened up the complexity of the question. The intricacies of the problem may mirror in part the vast complexity of the human brain, the secrets of which scientists have just begun to probe. The anatomical differences in the human brain have proved to be on a continuum, i.e., sometimes the difference between an area in one hemisphere and that area in the other hemisphere is small in a particular individual whereas the brain of another individual may show a large difference between the hemispheres in reference to that particular area. If and when sex differences in human brains become firmly documented, one would expect the same enormous range of differences within a particular sex. Just as there is a tremendous range of differences in characteristics of many types within a particular sex, there is also a great overlapping in these characteristics between the sexes. Brain research probably will confirm and is confirming this. Unless this is kept in mind, there is a great danger that this new research will serve as a source of further discrimination against women. Through it all the wisdom of Margaret Mead articulated over thirty years ago and cited above should not be forgotten. We need to look at the question as she did, in a manner that will call forth the potentialities of individuals, both as humans and as members of their particular sex.[53]

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NOTES

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[34]Restak, p. 198.

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[44]Mead, p. 380.

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[46]Mead, pp. 372-73.

[47]Mead, p. 374.

[48]Mead, p. 378.

[49]Mead, p. 374.

[50]Mead, p. 382.

[51]Mead, pp. 382-83.

[52]Mead, pp. 383-84.

[53]Since this manuscript went to press, several articles and books on the subject of brain difference between male and female have appeared. Among the best of these are: Robert W. Goy and Bruce S. McEwen, *Sexual Differentiation of the Brain* (Boston: The MIT Press, 1980); Pamela Weintraub, "The Brain: His and Hers," *Discover*, 2 (1981), 14-21.